ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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International Journal of Poultry Science 14 (7): 383-386, 2015
ISSN 1682-8356

Effect of Different LED Light Colors on Development of the Reproductive System of Quails

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Abstract: Light duration, intensity and wavelength are critical environmental stimuli affecting physiology and growth rate of birds. The objective of this trial was to evaluate the effect of emitting diode lux color (LED) as a source of artificial lighting for quail. The study used 120 quails (*Coturnix coturnix*) distributed in a completely randomized design in 20 cages, with five treatments (LED red, white, Blue, green and yellow), with four repetitions of six birds each, totaling 20 experimental units. Production indices were evaluated weekly: feed intake (g/bird/day), average daily gain (g/bird/day), feed conversion (g/g) and carcass yield (%). For the biometrics analysis of the reproductive system, the length of the oviduct and the total number of ovarian follicles was measured. Using the computer software ASSISTANT, the data were submitted to analysis of variance and the differences compared with Tukey test 5% in case of a significant effect. The results of feed intake, daily weight gain, feed conversion and carcass yield did not differ ($p>0.05$) between treatments. No differences were found between the average size of the oviduct and between the total number of follicles ($p>0.05$). Different colors do not influence the early development of the reproductive system of the quails (*Coturnix coturnix*), showing that it is possible to use the LED lighting system, for quail production.

Key words: Carcass yield, *Coturnix coturnix*, follicles, oviduct, performance

INTRODUCTION

The birds have highly developed visual systems and most of their behaviors are mediated by their vision (Mendes *et al.*, 2013). The lighting is a primary factor in the posture of the birds, whose function is to stimulate the development of the reproductive system and the locomotor activity of the bird to higher food and water intakes (Blatchford *et al.*, 2012).

Studies with laying hens (Gongruttananun, 2011; Borille *et al.*, 2013; Huber-Eicher *et al.*, 2013) and broilers (Zhang *et al.*, 2012; Kim *et al.*, 2013; Santana *et al.*, 2014), were developed with the replacement of lamps commonly used for light emitting diode (LED), seeking to improve the production rates of birds and economic savings in lighting system because LEDs may be used up to 50,000 h, i.e., much longer than incandescent and compact fluorescent lamps, which life is 1,000 and 8,000 h of use, respectively (Angelica *et al.*, 2012).

In addition to the lower cost of energy, LED different colors showed improvement in the development of the reproductive system and the indices of eggs quality (Gongruttananun and Guntapa, 2012; Borille *et al.*, 2013) to laying hens.

The replacement of incandescent lamps by sodium lamps lead to saves about 70% in the electrical energy costs. Other practices may reduce energy consumption even further, such as intermittent lighting programs applied in egg production or the use of new light sources available in the market, such as LED (light-emitting diode). This technology emits cold light and it is widely known for its high lighting efficiency and long life. LED is a semiconductor device that emits spatially incoherent light at a relative narrow frequency spectrum generated by an electroluminescence effect. The color of the bulb depends on the composition and condition of the applied semiconductor material and may range from ultraviolet to infrared (Carvalho, 2007).

There is a lacking of studies on the use of LED lamps for laying quails (Jacome *et al.*, 2012), no data were found in the literature correlating different LED colors on the development of quail reproductive system.

Considering that different LED colors can influence production parameters and physiological behavior of quails, the goal was to evaluate the yield performance and biometrics characteristics of quails reproductive system (*Coturnix coturnix*) exposed to artificial light with different LED colors.

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MATERIALS AND METHODS

Birds, housing and experimental design: A total of 120 quails (*Coturnix coturnix*) with initial age of 35 days. They were distributed in a completely randomized design in 20 cages (0.50 x 0.50 x 0.20 m), with five treatments (Table 1) and four repetitions of six quails each one in a total of 20 experimental units.

Table 1: Treatments, lux and frequency

Treatments	LUX	Frequency (nm)
Red LED	26	625-740
White LED	35	N
Blue LED	35	440-485
Green LED	32	520-564
Yellow LED	26	565-590

The evaluation period was from, 35 to 49-day-old birds (14 days). The choice of age for this experiment was based on the hypothesis that the females of this animal species generally begin their reproductive development to around 40 days of age, when the bird start to responds to the stimulus by light.

The cages were equipped with feed trough type and *nipple* drinker type, insulated with a black plastic sheet, so the light used per cage will not interfere the next cage. In this way a light bulb was installed LED PAR 20 of 1W power in each cage according to the previous described treatments. The lux measurement was taken using a digital light meter positioned at head height of birds in night shifts, without the interference of external light.

Temperature and relative humidity were recorded daily using two digital thermo-hygrometers placed at the birds' height in two equidistant locations. The average and absolute maximum temperatures was 30°C and 34.1°C, respectively, while the average and absolute minimum temperatures recorded were 18.6°C and 13.4°C, respectively. The average and absolute maximum relative humidity was 73.36 and 36.18% and the average and absolute minimum relative humidity was 27.82 and 15.00%, respectively.

The lighting system was connected to a timer in order to supply a continuous lighting program of 17 h/day (natural+artificial). Feed and water was provided *ad libitum*, the commercial feed was according to Table 2.

Table 2: Commercial diets guarantee levels, used during the evaluation period

Nutrient	Min/Max	%
Calcium	Max	4
Fat	Min	2.5
Phosphorus	Min	0.5
Fiber	Max	6
Ash	Max	11
Crude protein	Min	19
Moisture	Max	12.5

Enrichment per kg of product: folic acid (1 mg); Pantothenic acid (50 mg); antioxidant (125 mg); choline (400 mg); Copper (8 mg); iron (100 mg); iodine (0.6 mg); Manganese (120 mg); vitamin A (10,000 IU/kg); Vitamin B_{12} (5 micrograms); Vitamin D_3 (1.250 IU/kg); Vitamin E (50 mg); Vitamin K (3 mg); zinc (80 mg); niacin (60mg); biotin (0.2 mg); pyridoxine (6 mg); thiamine (4 mg); riboflavin (6 mg)

Quail performance and carcass yield: The performance parameters were evaluated weekly (corresponding with the ages of 42 and 49 days): feed intake (g/bird/day), average weight gain (g/bird/day) and feed conversion (g/g). The feed intake (g/bird/day) It were evaluated by the weight of the feed that remain on the last day of each study period (Feed Intake = (feed leftover/number of birds)/7 days). The average daily gain (g/bird/day) was evaluated weekly (AWG = ((initial weight-final weight) /n° birds/repetition)/7 days). The feed conversion corrected by daily mortality was calculated: (FC = FI/AWG).

At 49 days of age, eight birds per treatment were stunned with CO_2 and killed by exsanguination. The carcass yield (%) was calculated in relationship with the life weight before slaughter, {CY = [carcass weight (g) x 100] / live weight}.

Biometrics reproductive system: The length of the oviduct was measured with aid of a digital caliper and the number of ovarian follicles per bird.

Statistical analysis: Data were tested for the presence of outliers, studentized residual normality and variance homogeneity. After complying with these assumptions, the data were submitted to analysis of variance (5% significance level) using the Assistant (2013) and the Tukey test.

RESULTS

Quail performance and carcass yield: No difference in quail performance (feed intake-42 and 49 day-old, weight gain and feed conversion) was found (p>0.05) (Table 3).

Table 3: Feed intake, weight gain and feed conversion of quail according to the treatments

	FI (42 days)	FI (49 days)	Weight gain (g)	FC
LED (g/g)	---------------- (g/quail/day) ----------------			
Red	25.07	30.40	6.13	4.54
White	25.97	31.20	6.18	4.82
Blue	21.65	28.62	7.22	3.71
Green	24.67	31.05	5.35	4.58
Yellow	24.07	27.42	6.11	4.60
p-value	0.0971	0.6278	0.1733	0.6651
SEM	1.191	1.929	2.068	2.958
CV %	8.34	13.62	29.78	28.22

SEM: Standard error; CV: Coefficient of variation. FI: Feed intake FC: Feed conversion

Biometrics reproductive system: For the treatments no differences were observed (p>0.05) in length of the oviduct (measured at 42 and 49 days) and the number of ovarian follicles per bird at 49 days (Table 5).

DISCUSSION

This experiment was conducted to identify the effects of different LED light colors on the characteristics of quails: performance, carcass yield and early development of the quail's reproductive system.

Table 4: Carcass yield of quail according to the treatments

	Carcass yield (42 day)	Carcaca yield (49 day)
LED	------------------------------- (%) -------------------------------	
Red	70.75	74.47
White	71.50	73.50
Blue	69.75	74.00
Green	68.38	69.15
Yellow	75.36	70.26
P-value	0.7210	0.7613
SEM	0.876	0.592
CV %	5.12	8.55

SEM: Standard error; CV: Coefficient of variation

Table 5: Length of oviduct and number of follicles of quail according to the treatments

	Oviducto (42 days)	Oviducto (49 days)	No. of follicles (49 days)
LED	------------------------------ (cm) ------------------------------		
Red	4.21	12.24	6
White	4.24	17.07	10
Blue	4.07	9.29	2
Green	3.66	17.66	7
Yellow	4.25	13.83	8
p-value	0.9089	0.4753	0.1612
SEM	1.402	1.168	8.523
CV %	7.90	61.82	143.96

SEM: Standard error; CV: Coefficient of variation

According to Blatchford *et al.* (2012), the penetration of red wavelength radiation in the hypothalamus is more sexually stimulating than green or blue wavelength. This could explain the better performance of the birds under the red LED, white LED and incandescent lamp, as their visible spectrum included red. According to Mendes *et al.* (2010), incandescent light presents a red light aspect, whereas white fluorescent lights have a bluish aspect. The reason is that incandescent light produces longer wavelengths, close to red, whereas fluorescent lights produce shorter wavelengths, closer to green and blue. However, white is a homogenous mixture of all colors.

Feed intake, weight gain and feed conversion (Table 3) were not significantly influenced by the light LED. This indicated that birds had the same visual sensitivity to all tested light sources and did not change their feeding behavior in function of light color.

In conformity with these results and in previous trials with commercial layers, sources of light and different light colors Gongruttananun (2011), Jacome *et al.* (2012), Borille *et al.* (2013) and Huber-Eicher *et al.* (2013) had not checked differences in the development of the birds.

According to Blatchford *et al.* (2012), the effect of lighting on feed intake is associated to birds' locomotion activity, which reduces during dark periods. As movement/ locomotion is reduced, energy expenditure also reduces, resulting in a better feed efficiency with lower feed intake.

The results found with carcass yield were in average above the results founded by Mori *et al.* (2005) and in average lower than the results founded by Correa *et al.* (2005), the facts that could be related with this difference, can be associated with the differences in the genetic lines and feed behavior. Besides the use of specific genetic line, the use of males and females can also influence the production efficiency and the characteristic of the final product, in addition to the differences between strains, also had observed the importance of differences in weight between sexes, in which females were heavier than males of the same age.

Hassan *et al.* (2013), in a study with artificial lighting and different LED colors (red, blue, green and white) observed that birds exposed to red light had a more expressive weight of the ovary. These results suggest that longer wavelength light penetrates the skin and skull of the chickens to stimulate the pineal and pituitary glands, which control the secretion of reproductive hormones such as follicle stimulating hormone (FSH), luteinizing hormone (LH) and 17 estradiol (E_2); these hormones enhance the growth and number of ovarian follicles changing the development of the reproductive tract of birds exposed to the red LED (Mobarkey *et al.*, 2010; Er *et al.*, 2007).

However, the cited studies were performed during the birds egg production phase with different responses compared with this present study. Light intensity did not present to have an effect on development of the reproductive system of pre-laying birds. This result is relevant, as it evidences that lights of different wavelengths, do not influence the development of the quail's reproductive system.

Conclusions: The LED colors: red, white, blue, green and yellow, can be used in the raising of laying quails, once they had no interfere in the performance parameters and carcass yield. Different LED colors did not affect the laying start or quail's (*Coturnix coturnix*), reproductive development. It is concluded that, it is possible to use the LED lighting system, in order to minimize energy expenses with quail production.

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